Evaluation of the Learnability Principles of Mobile-Wireless Information Systems' Application Software for Children in Kenya

¹ Bethuel Kipchirchir Okelo, ² Samuel Mungai Mbuguah^{, 3} Simon Maina Karume ¹Masinde Muliro University of Science and Technology, ²Kibabii University College, ³Laikipia University ¹bkip101@rocketmail.com, ² smbugua@kibabiiuniversity.ac.ke, ³ smkarume@gmail.com

ABSTRACT

Mobile-wireless gadgets are becoming increasingly important in Kenya not just as a medium of social communication, but also as a medium of learning and instruction. This shift partly exploits the learnability principle in information technology, which signifies how quickly a new user can begin efficient and error-free interaction with a system. The learnability principle was originally formulated for computer-based applications intended for adults, but currently children are increasingly becoming the end users. A gap exists in research on the effects of learnability on school-aged children in urban areas of Kenya. Against this backdrop, this study aimed at gathering information on the learnability characteristics of children of different age groups. The research further explored the degree to which the mobile-wireless information systems' applications software learnability principles are applicable to children in Kenya. The study site was Nairobi and the research participants were children ranging between the ages of 8 to 19 years. Data collection involved questionnaires and the use of tests. The research was in the form of an experiment to evaluate certain factors that affect learnability in relation to the age of the participants and their level of computer experience. The research data was recorded and analyzed by Morae, a learnability software. Major findings indicate that children between the ages of 8 and 14 years require engageability to improve their learning by using new application software, this does not mean that other users of a different age do not require this principle but the degree to which it affects them is different. As for the older kids 15 to 19 years, the findings indicated that they strongly require discoverability to improve their learnability of new application software, this does not mean that adults or children of different ages do not require this given principle but to say the degree to which it affects them varies.

Keywords: Information systems, learnability, learnability principles, application software, discoverability, engageability.

1. INTRODUCTION

The principles and guidelines for software design are generally aimed at products for adults, with the emphasis on improving work performance and productivity [1]. As [2] found out, designers of children's technology and software face distinctive challenges. Many design principles used for adult interfaces cannot be applied to children's products because the needs, skills and expectations of this population segment are drastically different than those of adults. People of different ages learn how to use these systems in a different manner and period of time. For example, children from the ages of 8 to 14 years old like playing video games while those above 15 years old like instant messaging on social networking sites although both groups in general like to explore and are inquisitive, this makes them learn how to use these systems very fast, while we may find people from the ages of 60 years and over hardly try out new functions on their systems, thus they only use the systems for specific purposes, thus making them learn the system over a long period of time or may not at all learn to use the system efficiently. The researcher had set out to evaluate if the current learnability principles suit the different children age groups by enabling efficient and effective use of mobilewireless information systems application software and to examine how the learnability of mobile-wireless information systems' application software can be improved to suit the different users' age group.

1.1 Scope of the Study

The research was conducted in Nairobi County in Kenya an urban county with expanding usability in information communication and technology. Nairobi is an IT hub in East Africa and therefore, more children are exposed to ICT systems. The research focused on children of the age groups of 8 to14 years and 15 to19 years, because children at different ages learn differently thus different learnability issues [4].

2. RELATED STUDIES

Nielsen (1994) defines learnability as a novice user's first experience of learning. He states that a learnable system could be categorized as "allowing users to reach a reasonable level of usage proficiency within a short time". Additionally, it includes the time it takes users to learn how to use the commands relevant to a set of tasks or the effort required for a typical user to be able to perform a set of tasks using an interactive system with a predefined level of proficiency [3].



Figure 1: Internal and external qualities of a system and usability characteristics. Source: [5]

To measure learnability, ISO Standard 9241-111 provides the following guidance on measuring learnability. Effectiveness measures: number of functions learned; percentage of users who manage to learn to criterion. Efficiency measures: time to learn to criterion; time to re-learn to criterion; relative efficiency while learning. Satisfaction measures: rating scale for ease of learning. Other measures include: Error counts; error recovery time; the time that a new user needs to reach a predefined level of proficiency.

Table 1: Learnability definitions. Source: [27]

Nielsen	Novice user's experience on the initial
1993	part of the learning curve.
Dix (1998)	Ease at which new users can begin
	effective interaction and achieve
	maximal performance
Santos and	Measure of the effort required for a
Badre	typical user to be able to perform a set
(1995)	of tasks using an interactive system
	with a predefined level of proficiency.
Hart and	The speed and ease with which users
Steveland	feel that they have been able to use the
(1988)	product or as the ability to learn how
	to use new features when necessary.
Bevan and	A measure of comparison the quality
Macleod's	of use for users over time.
(1994)	
Butler	Initial user performance based on self
Butler (1985)	Initial user performance based on self instruction" and "[allowing]
Butler (1985)	Initial user performance based on self instruction" and "[allowing] experienced users to select an
Butler (1985)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or kaystrokes
Butler (1985)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes.
Butler (1985) Kirakowski	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the
Butler (1985) Kirakowski and Claridge	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its
Butler (1985) Kirakowski and Claridge (1998)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its first use
Butler (1985) Kirakowski and Claridge (1998) ISO_9126-	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its first use. The canability of the software product
Butler (1985) Kirakowski and Claridge (1998) ISO 9126- 1 (2001)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its first use. The capability of the software product to enable the user to learn its
Butler (1985) Kirakowski and Claridge (1998) ISO 9126- 1 (2001)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its first use. The capability of the software product to enable the user to learn its application
Butler (1985) Kirakowski and Claridge (1998) ISO 9126- 1 (2001)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its first use. The capability of the software product to enable the user to learn its application
Butler (1985) Kirakowski and Claridge (1998) ISO 9126- 1 (2001) ISO 25010 (2011)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its first use. The capability of the software product to enable the user to learn its application Degree to which a product or system can be used by specified users to
Butler (1985) Kirakowski and Claridge (1998) ISO 9126- 1 (2001) ISO 25010 (2011)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its first use. The capability of the software product to enable the user to learn its application Degree to which a product or system can be used by specified users to achieve specified goals of learning to
Butler (1985) Kirakowski and Claridge (1998) ISO 9126- 1 (2001) ISO 25010 (2011)	Initial user performance based on self instruction" and "[allowing] experienced users to select an alternate model that involved fewer screens or keystrokes. Within the web context is the degree to which users feel able to manage the product's basic functions during its first use. The capability of the software product to enable the user to learn its application Degree to which a product or system can be used by specified users to achieve specified goals of learning to use the product or system with

journai.org			
	effectiveness,	efficiency,	freedom
	from risk ar	nd satisfaction	on in a
	specified contex	xt of use	

According to [6] learnability can be measured by investigating various factors such as: User interface: visibility of operation; feedback; continuity of task sequences; design conventions; information presentation; user assistance; error prevention, Conformity of user's expectations: differences in functionality; differences in interaction styles; concept clarity; completeness of information, Training: Conceptual information; exercises; instruction of basic interaction; instructions for solving problems; motivational content; coverage of system functionality and material types.

2.1 Existing Principles

A survey of Software Learnability Metrics, Methodologies and Guidelines were done by [7]. The survey explored the previous definitions, metrics, and evaluation methodologies which have been used for software learnability. Their first goal and contribution was providing a thorough survey of the existing learnability research, generalize the results into consistent frameworks and taxonomies, and providing recommendations for the evaluation of software learnability. This survey resulted in the development of a new question-suggestion protocol for learnability evaluation, which they first described, and then explored, in a user study. Their study revealed that in comparison to a traditional think-aloud protocol, the question-suggestion protocol is a more efficient methodology for identifying learnability issues in software. There is an existing learnability framework that was designed for a given niche this being adults in general. Because of this the researcher investigated different ways to improve learnability of these systems to suit children of different age groups depending on the dominant learnability factors of the given cohort in this case being children between the ages of 8 to 19 years as mentioned in the scope of the study. By the end of the research, give subprinciples for each age group as a recommendation for the vendors to adopt. This will also help institutions like the Kenyan government now that they are propose to give free laptop to young children.

Another study on learnability by [8] compared the meaning of learnability for child and adult users. The lack of relevant information in the literature dealing specifically with the learnability principle suggested a gap in the body of knowledge. The research was an attempt to fill this gap and improve the granularity in the description of the learnability sub-principles. The comparison of the meaning of the learnability principle for children and adults using an unfamiliar software application yielded significant results for software designers and HCI practitioners in general. Thus they came up with a new learnability sub-principle known as engage ability. The word engage ability was derived from the word engagement which is in the HCI context, engagement is a goal of interface design; it is also the



main focus in the well-established frameworks of flow theory and play theory [9]. Engage ability occurs when a person loses himself or herself in an activity, losing all track of time and not noticing anything outside of the activity. The end result ultimately aided in the reformulation of the learnability principle in a way that distinguishes between the needs of adults and children.

The way in which learnability and its subprinciples are currently defined, makes it difficult to clearly separate its application to different age groups. This has left a gap in the learnability of children at different ages, since children at different ages learn differently [10] thus the research will have age groups of children ranging from 8 to 19 years that is testing each principle on the given age groups.

3. RESEARCH METHODOLOGY

This section discusses the methodological approach including the research design, instruments used, data collection techniques, study location, and target population. The research was aimed at improving the learnability of children in the use of application software that are mainly used in mobile-wireless information systems. Thus the research was in the form of an experiment/test.

3.1 Research Design

According to [11], research always takes place in a specific context. The way the researcher views the context will depend on the research paradigm. The researcher used the Positivists approach in the design, in which the research is mostly experimental and qualitative, usually try to control and manipulate the context of the research.

3.2 Location of the Study

Data was collected in Nairobi County which has eight constituencies namely: Makadara, Kamukunji, Starehe, Lang'ata, Dagoretti, Westlands, Kasarani and Embakasi. Nairobi East, Nairobi North, Nairobi West and Westlands districts were mapped to this county for the purposes of generating county estimates. Data was collected within the residential areas.



Figure 2: Map of Nairobi County. Source: (Google Maps)

Participants were identified and drawn from the local shopping centers and schools. Parental and guardian permission was granted prior to children participating in the study. Nairobi was chosen as an ideal study site because it is the country's ICT hub thus a convergence $_{o}$ f technology and it is the most rapidly growing town in terms of ICT. Additionally, children in such an urban county are likely to have access to these systems compared to rural communities whereby the children may not have been sufficiently exposed.

3.3 Target Population

The target population included children between the ages of 8 and 19 years living in Nairobi County.

3.4 Sampling

The research was in the form of an experiment as mentioned earlier thus had a calculated number of test subjects (human participants) to attain the necessary data required for the evaluation and analysis of the application software.

The researcher used a usability sample size calculator provided by www.blinkux.com to get the recommended sample size for the learnability study through the use of determining factors such as: the number of different groups of users that will be compared in the study (this being –age group); users performing the same or different tasks; if the results of the study would be used to compare against future studies; the number of designs that would be compared in the study; the number of designs that each participant will evaluate; and if eye tracking will be used in the study.

Blink is a user experience research and design firm. Blink's usability testing services include heuristic evaluations, usability testing, and eye-tracking research. By use of the calculator the researcher derived a population sample size of 20 participants. According to [12] for many usability testing situations 5 to 15 participants should be adequate to detect many design flaws. When cost of failing to find a flaw is high –for instance when safety could be compromised– then more participants should be tested. This explains the approach used to collect the data from the selected target population within Nairobi County. Cluster sampling was used by the researcher to pick children in groups of 3 or 4 from different institutions and giving them the test.

Table 2: Research locations

Area	School	Level			
Langata	Heritage School	Primary and Nursery			
Lavington	Lavington Mixed	Secondary School			
Lavington	Muthangari	Primary School			
Kawangware	Hope Center	Secondary			
Westlands	Aga Khan	Secondary			

The areas listed in the table were chosen randomly thus socio-economic status was not a factor i.e. high, middle or low-income status of the institutions was not a determinant in choosing the test candidates.

These are the various ways that the researcher gathered the necessary information needed to do a good analysis of the problem at hand by collecting qualitative data. The researcher gave the subjects the following instructions to follow which depended on the age group they belonged to:

For participants (15-19) years

a. WhatsApp Messenger

- i. Add a new contact on the phone or use an existing contact
- ii. Send a WhatsApp message to the contact –the new or the existing contact (Task A)
- iii. Attach and send a photo to the contact (Task B)

b. Facebook

- i. Log in to Facebook or sign up (Task C)
- ii. Update status on the Facebook account (Task D)
- iii. Search for a person on Facebook and send a friend request to them (Task E)

c. Repeat procedure A

NOTE: You do not have to follow any particular order in performing the given tasks

For participants (8-14) years

- i. Start angry birds, play and complete any two levels (Task F & G)
- ii. Play subway surfer (Task H)

NOTE: Start with any game you prefer

3.5 Primary Data Collection

Questionnaires: This were used to gather the necessary data from a large number of the targeted group so as to have sufficient information for analysis within the limited time the researcher had available. This was supplemented by the experiments in order to achieve the first objective.

These questionnaires were administered by use of the morae software at the beginning of the test and at the end of the recording of the test.

Experiments (observations in both a controlled and free environment): This was used to find out what learnability factors are dominant in children and which are not from the known learnability factors and principles. The experiment and questionnaires were administered and tested by Morae 3.3.3 software to record the tests and at the end of the test display the questionnaire for answering by the participant.

3.6 Software Used in the Testing

The four application software used in the testing are Facebook, WhatsApp Messenger, Subway Surfer and Angry Birds.

Facebook: It is an online social service network. The founders had initially limited the website's membership to Harvard students, but later expanded it to colleges in the Boston area, the Ivy League, and Stanford University. It gradually added support for students at various other universities and later to their high-school students. Facebook now allows anyone who claims to be at least 13 years old worldwide to become a registered user of the website, although proof is not required [13].

WhatsApp Messenger: is a proprietary, cross-platform instant messaging subscription service for smart phones and selected feature phones that uses the internet for communication. In addition to text messaging, users can send each other images, video, and audio media messages as well as their location using integrated mapping features.

Subway Surfer: It is an "endless running" mobile game. Players of the game take the role of youthful hooligans who, upon being caught in the act of applying graffiti to a metro railway site, take off down the tracks to escape the inspector and his dog. As the hooligan avatars run, they grab gold coins out of the air while simultaneously dodging collisions with railway cars and other objects.

Angry Birds: It is basically a game of sketches of stylized wingless birds. In the game, players use a slingshot to launch birds at swine stationed on or within various structures, with the intent of destroying all the swine on the playing field. As players advance through the game, new types of birds become available, some with special abilities that can be activated by the player.

Data was collected through Morae 3.3.3 a learnability software that records a picture-in-picture (PiP), eye-tracking, video recording and sound recording. The software by use of the PiP enabled the researcher to record the participants' screen activities which helped the research during analysis to go through the recordings repeatedly to find problems and to also further find problems that were not previously seen. The software has 3 components basically i.e. Morae Recorder; Morae Observer and Morae Manager. The researcher used the recorder for data collection and later used the manager for the analysis. The manager has markers which the researcher used to mark within the recording where there is an error, where a task was completed successfully, where the participant required assistance and so on.

Genymotion: A virtual machine that was used as a platform to host the mobile phone/ tablet emulator on the computer finding out the existing gaps and what approach to take to do the research.



Figure 3: Illustration of Morae 3.3.3 recording process.

3.7 Secondary Data Collection

This involved collecting data from documents, records and reports of others. This facilitated the researcher on what approach to take in investigating the learnability by gathering the available information and

Table 3: Demographics of the younger participant in the learnability testing according to the first questionnaire answered.

Source:	Author

Participants	Gender		Age	Education	Angry birds	Subway surfer	P	revi wi	ous experience th computer
	М	F		PRI	Y	Ν	Y	Ν	1-10
SMALL KID 1		Х	13	Х		Х		Х	5
SMALL KID 2	Х		12	Х	Х			Х	3
SMALL KID 3	Х		15	Х	Х			Х	4
SMALL KID 4		Х	11	Х		Х		Х	2
SMALL KID 5	Х		15	Х	Х		Х		3
SMALL KID 6		Х	8	Х	Х			Х	4
SMALL KID 7	Х		11	Х	Х			Х	4
SMALL KID 8		Х	11	Х	Х		Х		5
SMALL KID 9	Х		9	Х	Х		Х		5
SMALL KID 10	Х		9	Х	Х			Х	4

 Table 4: Demographics of the older participant in the learnability testing according to the first questionnaire.

 Source: Author

Participants	Gender	•	Age	Education	Whatsapp		Whatsapp		Whatsapp Faceb		hatsapp Facebook		Previous experience with computer
	М	F		SEC	Y N		Y	Ν	1-10				
BIG KID 1	Х		16	Х		Х	Х		5				
BIG KID 2	Х		17	Х	Х		Х		3				
BIG KID 3		Х	16	Х		Х		Х	4				
BIG KID 4	Х		19	Х		Х	Х		2				
BIG KID 5		Х	18	Х	Х		Х		3				
BIG KID 6		Х	19	Х	Х		Х		4				
BIG KID 7	Х		16	Х		Х	Х		4				
BIG KID 8	Х		16	Х		Х	Х		5				
BIG KID 9	Х		16	Х		Х	Х		5				
BIG KID 10	Х		17	Х	Х		Х		4				

3.8 Heuristics Evaluation

The researcher used heuristic evaluation based on Jakob Neilensen's 10 heuristics evaluation guidelines to evaluate the interfaces of the application software used by the participants for the learnability testing. According to [14] two to three analysts usually evaluate the system with reference to the 10 established heuristic evaluation guidelines, noting down their observations and often ranking them in order of severity.

3.9 Discussion

From the data gathered by the questionnaires and the heuristics evaluation in this chapter, the researcher clearly found out that the children of the different age groups used different application software and so they were evaluated differently i.e. the social applications used by older kids were evaluated by the 10 heuristics evaluation guidelines by [14] while the video games used by younger kids could not be evaluated by the same guidelines thus playability heuristics were used to do the evaluation. There were tangible interface issues in violation of the heuristics guidelines that the evaluators got to observe and evaluate thus clearly showing that there were problems with the existing user interfaces. In the next section the researcher analyzed the video recordings of the participants to find out if the observed user interface issues affected the participants; which learnability principle they fall under and the extent to which the principles are a cause of the learnability issue.

4. RESULTS ANALYSIS AND DISCUSSION

4.1 Categorization of Learnability issues According to the Existing Learnability Principles

Awareness of Functionality: A typical problem was that some users were not aware of a specific tool or operation which was available for use (familiarity problem).

Locating Functionality: This problem occurred when the user was aware of a certain operation which the system possessed, but could not figure out where to find it in the user interface, so that it could be utilized (generalizability and consistency problem).

Understanding Functionality: This problem means that users were aware of a single, specific, tool or function, able to locate it, but could not figure out how to use it (predictability and synthesizability problem).

 Table 5: Summary of the errors committed by the participants according to the existing learnability principles.

 Source: Author

Participant	Pc use (1 - 10)	Errors	Assistance	Task time(min)
BIG KID 1	5	1	1	22:58
BIG KID 2	9	0	0	13:48
BIG KID 3	3	4	3	21:58
BIG KID 4	1	5	4	15:24
BIG KID 5	3	4	5	24:48
BIG KID 6	3	0	2	19:19
BIG KID 7	5	1	0	14:41
BIG KID 8	3	5	2	16:04
BIG KID 9	1	7	2	21:09
BIG KID 10	3	2	3	20:15

4.2 Percentage of the Categorized Problems

Percentage of the learnability issue = total of the given principle error / total number of issues (errors) * 100

% Familiarity principle errors = 8/29*100 % Familiarity principle errors = 28 (27.586) Familiarity issues = 28%

% Generalizability & consistency errors = 14/29*100 % Generalizability & consistency errors = 48 (48.276) Generalizability and consistency issues = 48%

% Predictability & Synthesizability errors = 7/29*100 % Predictability & Synthesizability errors = 24 (24.138) Predictability & synthesizability issues = 24%







4.3 Differences and Similarities between Younger and Older Kids

Video games are the only applications younger kids are interested with in mobile devices while older kids prefer to use social apps in the devices: As the researcher was testing the participant the researcher asked the younger user through a questionnaire if they have ever used any of the social applications, these being Facebook, WhatsApp and any other that they knew or heard of from friends, older siblings or at home. 9 out of the 10 younger participants had never used these application software and were not interested in using these application there was only one who said that he tried to register to Facebook but his parent objected and that's how far he managed to try such an application. From these we realize that younger users these being of ages 8 or earlier to about 14 years do not use and are not interested in the use of social applications at this age.

i. Younger kids like applications that engages them such as video games: The younger kids that were tested of ages 8 to14 years are interested in mobile applications that engages them such as video games, fun and entertainment apps such as: talking tom and so on whether educational or not. Children of the above mentioned ages prefer applications that have factored engage ability into their systems. Engage ability occurs when a person loses himself or herself in an activity, losing all track of time and not noticing anything outside of the activity [11]. Engage ability is a learnability principle that [11] derived through investigating the difference in meaning of learnability of children and adults. This is evident in the picture-in-picture video recordings of the young children when they were trying a new application software (in this case a video game) namely -subway surfer. From the videos the researcher realized that the children were consumed in the game entirely even though failing in several attempts the game engaged them with the running and dodging of trains until they started learning how to dodge the trains and other obstacles in the game. This shows how important the engagement factor is in learn of a new application for the younger children. Although the game had several heuristics violation it helped in identifying certain aspects that the researcher had anticipated.

Older kids have a preference in what application software they want to use while younger kids will use any application software so long as it is fun: The older kids this being from about 15 years to 19 years are selective in which mobile applications they use reasons being: what value it adds to them i.e. 1) social status –a child at this age would not want to be the only one not using these popular apps, 2) its purpose for example it is cheaper to communicate using WhatsApp to peers compared to sending text messages directly (it basically costs less). The older kids also play mobile games to pass time but they mainly use social apps on mobile phones most of the time. As for the younger kids they will use any application so long as it is fun they do not consider any external factors such as other people's opinions or perceptions.

Older kids find it difficult performing certain functions because of the location of certain icons: The older kids in this case children of ages 15 to 19 years were unable to perform certain tasks within good time and without assistance due to location of some functions. For example uploading images in WhatsApp messenger was a problem for most of them even after being assisted, they still could not upload the image. This is a 'recognition not recall violation'. The same could be seen on the Facebook mobile app. The users were unable to see some icons since they are in a hidden menu unlike in the main Facebook site. The users could only see the newsfeed thus limited control. This is a 'user control and freedom violation'

Older kids found certain mechanisms of the application software appealing and very helpful in performing the tasks required: When a user tries to use the search functionality on the Facebook mobile app, the user may not need to type the whole word in order to find what they are searching for i.e. the search brings up suggestions of what is being searched for. This can also be seen in the case whereby the user is in multiple groups. The application will first display the groups that the user is most active on first in the list. If you usually like comments of a specific persons post more than others, the app will provide more of the person's posts in the users feed. This really facilitates the 'efficiency and flexibility heuristic guidelines' This can also be seen on the WhatsApp messenger application when a frequently used emoticon is usual on top of the list that is the first to appear when a user wants to use an emoticon on a message. Other mechanisms that assisted the user were such as: asking a user the location where a photo was taken when a user uploads photos or to tag the people in the photos or to add a caption on the photos and so on, this assisting the user to perform a task efficiently.

Younger kids never asked for help while performing the tasks at hand whether they were succeeding or failing: The researcher observed that the younger children that is of ages 8 to about 14 years never asked for assistance during the test they simply used trial-anderror tactics to try and achieve their goal. Although in the beginning the researcher assisted them and told them what is required of them as per the test instructions just to ease them.

Older kids prefer applications that facilitate in their interaction with their peers socially than in any other aspect (social apps) i.e. academically, economically etc. The older kids mainly prefer social apps over any other type of app since it resembles real-life interaction with their peers i.e. sharing photos and other personal information such as their feelings, sharing a joke, passing on information; how they felt about certain events or a person's opinion, forming groups etc. This brings out the aspect of the familiarity principle whereby it supports or

motivates the user to use this kind of application software.



Figure 5: Apps that teens use the most. Source: [15]

Both younger and older kids depend on past interactions to learn to use new software applications: When the younger kids try out a new software (in this case a new video game), they try and apply their knowledge of their previous interaction with video games by trying the in the new game i.e. trying out the same controls if it is the a game of the same nature e.g. racing video games, free running video games, shooting video games. From this insight we realize that the familiarity and generalizability principles strongly apply to the younger kids. As for the older kids, consistency in the layout by use of conventional standards is the most important learnability principle for them as inconsistencies as observed in the WhatsApp messenger app is a big problem for their learning a new application, consistency being supplemented by the generalizability principle.

Implications of the findings to the learnability principles Predictability: as mentioned in an earlier section, predictability is basically support for the user to determine the effect of future action based on past interaction history. According to the second finding, the younger kids are not affected by predictability as they mainly use trial-and-error approach towards the applications in this case being video games. Unlike the older kids who depend on predictability to facilitate their navigation by use of the heuristic guidelines such as: visibility of system status; recognition not recall to attain their goals. The application software facilitated this principle as seen from the test conducted that there was very little 'understanding functionality issues'.

Synthesizability: This is basically the support for the user to assess the effect of past operations on the current state. This also majorly affects the older kids as compared to the younger kids.

The younger kids will still use trial-and-error to discover new ways and approach of attaining their goals, this can be seen in finding 6 and in figure 5 that clearly showed the comparison between the number of attempts by the younger kids against the task completion. Thus this principle is of less importance to the younger kids. This principle is derived from the heuristic guideline 'recognition not recall'. The application software used by the older kids facilitated this principle as seen from the test conducted that there was very little 'understanding functionality issues'.

Familiarity: This is basically the extent to which a user's knowledge and experience in other real-world or computer-based domains can be applied when interacting with a new system. This principle is derived from the heuristic guideline 'Match between the system and the real world'. This is evident in finding 7 that kids prefer applications that resemble real-life that is social apps mainly since it facilitates their interactions with their peers. This is an important principle in the design for applications for kids of ages about 15 to 19 years. Familiarity can be considered as 'consistency' with past real-world experience. This principle affected the older kids in the categorization of learnability issues it fell under 'awareness of functionality issue' in which it consisted of 28% of the total issues/problems that the participants had.

Generalizability: It is the support for the user to extend knowledge of specific interaction within and across applications to other similar situations. This principle is derived from the heuristic guideline 'consistency and standards'. This principle is very important to both age groups this being older and younger kids of ages (15-19years) and (8-14 years) respectively. When generalizability is taken into account the users find it a lot easier to learn a new application software for example, if different games of the same type e.g. racing game have the same kind of controls be it a new game the users will easily learn how to play the game with little effort. For the case of social apps when conventional standards are used i.e. layout, icons location for example log out location, help and settings location etc. the user will easily navigate through the app with ease while learning how to use new and unfamiliar features. So this is a key learnability principle for applications for children of all ages. Generalizability as 'consistency' with experience with the same system or set of applications on the same platform.

Consistency: This principle is similar to the generalizability principle. It is the likeness in input/output behavior arising from similar situations or similar task objectives. This is also the use of conventional standards to facilitate the learnability of new application software i.e. layout, icons location for example log out location, help and settings location etc. It is also derived from the heuristic guideline 'consistency and standards'. This principle is of great importance in the learnability of children in both age groups. In findings 3 and 7 we realize that older children prefer to use specific type of app this being social apps. With this, the designers should strive to use the consistency principle to build consistency and standards in their applications in order to facilitate



learnability of the application software. This principle really affects the learnability of older children this is illustrated by the researcher in table 5 in chapter 5 whereby this principle was the cause of 48% of the total problems/errors that the participants had while performing the test.

Engageability: It occurs when a person loses himself or herself in an activity, losing all track of time and not noticing anything outside of the activity [11].

Engageability is thus associated with flow [16], which occurs when individuals are so engrossed in an

activity that they do not want to stop. It is the extent to which a software application can fully engage the user by providing a complete and satisfying user experience. Depending on relevance and context of use, a user interface that adheres to the engage ability principle will enable users to be self-regulated, to define their own learning goals and to evaluate their own achievements [11]. As it was realized in finding 2, younger kids like applications that engage them in activities such as video games which requires them to perform certain tasks and rewards them.

Sub-principles		Findings							
	Young kids prefer video games older kids social apps	Young kids like apps that engage them	Young kids use any fun apps old kids are selective on the apps to use	Location of icons problem for older	Mechanisms support older kids	Younger kids use trial-and-error without help/assistance	Older kids use apps that facilitate social interaction	Younger and older kids depend on past interaction to learn	
Predictability							Х		
Synthesizability				Х				Х	
Familiarity						Х	Х	Х	
Consistency				Х		Х		Х	
Generalizability				Х		Х	X	Х	
Engage ability		Х				Х			
Discoverability		Х			Х	Х			

4.4 Reformulation of the learnability principles

It is evident from the above discussion of the findings of this study that the sub-principles of learnability can be applied differently for children at different ages. In summary: Predictability to older kids is a key factor to better learnability as they depend on this principle to assist them in performing their tasks. Meanwhile, the younger kids do not rely on the principle since they mainly prefer using the trial-and-error approach to achieving their tasks. Synthesizability just like predictability to the older kids, it is an important principle in helping them perform their tasks unlike kids who use the trial-and-error approach mostly to perform tasks. Familiarity principle was also observed to be an import factor in the older children (15-19 years) learnability since it facilitated the 'match between the system and the real world' heuristic guidelines thus a good app that is targeted to the kids of this ages should apply this since it will help the new user to relate the system to their real-life experiences and thus making them learn how to perform tasks much faster. Consistency and generalizability principles both were key

principles to both the children's age groups (8-14years) and (15-19years) the two principals were derived from the 'consistency and standards' heuristics guidelines this being certain layout standards, command keys, game controls follow a certain order and thus works in a similar way across various platforms and applications. This enables both groups to learn how perform their even faster thus improving learnability.

Discoverability: This is the ability for users to locate something they need to complete a certain task. This can be seen in finding 5 which was that older kids found that certain mechanisms in application software facilitate their task performance in order to get to their desired target. From figure 4 we can see that the 'location functionality issue' that is based on the generalizability and consistency principles was the main contributor to the problems that the older kids had since it contributed to 48% of the whole problems that they faced. This was evident in the Facebook application whereby when the user uploaded photos they were asked if they wanted to add a caption or to tag the people on the photos. When



the user also searches for someone or something in the search bar on the application, it brought up suggestions of what the user was searching for. From this the researcher realized the importance of discoverability in the assistance of the user to attain some of their tasks. The discoverability aspect can also be seen in Microsoft word, when one highlights text, just next to the cursor a small font bar will appear with options to: bold, underline text, change font color and so on. This will assist a new user who has no idea of how to locate these option at the bar on top of the word processor. This supports the 'flexibility and efficiency use' and 'visibility of system status' usability heuristics guideline. The visibility characteristics of a software feature are the essential contributors to its discoverability. Every feature is concretely visible in the form of user interface controls and/or activity in I/O devices [17].

4.5 Recommendations for Practice

The researcher will conclude on a practical level by providing recommendation for software design based on the results of the research.

- a) Generally children's software should be designed with a multi-layered interface i.e. (most children software not just video games) thus a novice kid can start with the use of the simple layer that would just have the main or primary functionalities of the application, then as they gain confidence they can opt to the more complex interface that has more functionalities this being secondary and even tertiary functionalities.
- b) Software should be designed so that, even if instructions are available, users can use the software without instructional guidance. Software intended for children should not rely on written instructions only, but should allow for trial-and-error techniques to be followed. Software for adults, on the other hand, should provide detailed instructions and "help" facilities.

Discoverability should be factored in children's applications especially for those of ages about 15 years to 19 years. Since it strongly factors in their quick learning and efficient use of new application software. Discoverability can be applied to application software in different was namely: 1) exploitation of physical characteristic: According to [18] certain types of content may have physical characteristics that can aid to discoverability. These characteristics may be grounded in real world physics (e.g., we expect a sphere to spin); 2) spring into action: This can be implemented by the use of animation although the animation should not be overdone because it may instead of facilitate it may cause confusion thus making it unclear on where the user should focus, but when strategically introduced they can assist users by revealing features and teaching users how to interact with them; 3) provide sneak peeks: Instead of making primary and secondary functionality equally discoverable at all times, an effective strategy is to provide sneak peeks into the secondary functionality. Not only does this allow the user to focus on the primary task, but it may make it easier for designers to make optimal use of the limited screen; 4) just-in-time features: Another option is to anticipate when users will need a particular feature and display it at that time. To illustrate, take a look at the Pulse application. When the user reaches the end of an article, the navigation bar is maximized, providing access to other articles in that section. If Pulse were to show the navigation bar at all times it would clutter the interface, but more important, the user probably doesn't need to see all the other articles while they are reading. It's worth noting that Pulse doesn't prevent users from accessing the navigation bar while reading; they can always reveal the navigation by tapping on the small black tabs; 5) spell it out: in the 'help' and 'Getting started documents', the software designers should create emphasis on the new feature or the feature that users frequently ask questions about online by making them more visible in the documentation; 6) leverage mental models: Designers' understanding of how something works-make it easier for their users to discover app features and functionality. For example, most iPad eReader apps use the mental model of the physical book. There are no navigation buttons, but the book's graduated edge suggests that page turning is possible [18].

More emphasis should be put on engage ability of application software for children of ages between 8 years to about 14 years. Since most children use the trialand-error approach towards trial of a new software thus engage ability will definitely improve their learnability.

5. CONCLUSION

Learnability comprises specific measurable attributes and can be evaluated by measuring them in a real-life context. The researcher tested 20 participants with the aim of: i) evaluating the existing learnability principles of mobile-wireless information systems' application software that vary with different ages of children. By examining the softwares that different users use; finding the problems in the applications interfaces through heuristics evaluation and questionnaires ii) examining how the learnability of mobile-wireless information systems' application software can be improved to suit the different users' age group by doing analysis of the questionnaires and heuristics and find out what is common; what is a learnability issue and how can it be rectified and coming up with a principle that can accommodate the children of the given age groups and thus improve learnability. The researcher finally came up with a principle that extended the learnability principles so that it could properly cater to children of different age groups learning how to effectively use application software.

6. FUTURE RESEARCH

Further research is required to get more information on playability as part of learnability of application software specifically for video games.

Playability is the ease by which the game can be played or the quantity or duration that a game can be played and is a common measure of the quality of gameplay. For example, to determine what the impact of context of use would be on its effectiveness or applicability. Further research should also be done to see if discoverability applies to adults and not just adults in general but adults at different ages especially those of 60 years and over as it does to children.

According to [19], mobile devices have much potential to support older adults in their daily lives. However older adults have reported that they find mobile devices, such as existing mobile phones, difficult to learn to use. They argue that more research is needed to improve the learnability of mobile software applications for older adults.

REFERENCES

- [1] Pretorius, M., Gelderblom, H. J. & Chimbo, B.(2010). Using Eye-Tracking to compare how adults and children learn to use an unfamiliar computer game. In SAICSIT, Bela Bela, South Africa: ACM Press.
- [2] Chiasson, Sonia & Gutwin, Carl (2005). Design Principles for Children's Software, Technical Report. HCI-TR-05-02, Computer Science Department, University of Saskatchewan.
- [3] Shneiderman (1997). Introduction to Human Computer interaction
- [4] Roger Greenaway (2011). Reviewing Skills Training Retrieved from: http://reviewing.co.uk/articles/reviewing-fordifferent-ages.htm
- [5] ISO/IEC 25010:2011 Retrieved from: http://www.iso.org/iso/home/store/catalogue_ics/ca talogue_detail_ics.htm?csnumber=35733
- [6] Beginners,(2nd.ed.),Singapore, Pearson Education.
- [7] Tovi Grossman, George Fitzmaurice, Ramtin Attar, (2009). A Survey of Software Learnability: Metrics, Methodologies and Guidelines
- [8] Bester Chimbo, J H Gelderblom and M R De Villiers (2011). Engage ability: a new subprinciple of the learnability principle in humancomputer interaction.
- [9] Neil Charness, George Demiris, Elizabeth Krupinski (2011). Designing Telehealth for an aging Population: A Human Factor Perspective. Publisher: CRC press
- [10] Inhelder, Bärbel and Jean Piaget (1958). The Growth of Logical Thinking from Childhood to Adolescence. New York: Basic Books.

- [11] Bester Chimbo (2011). Comparing the meaning of the learnability principle for children and adults Retreived from: http://uir.unisa.ac.za/bitstream/handle/10500/4682/ dissertation chimbo b.pdf?sequence=1
- [12] Nielsen, J. (1994). Usability Engineering c Press. Boston MA
- [13] Facebook.com (November 22, 2011) "Information For Parents and Educators". Retrieved from: www.Facebook.com/help/parents
- [14] Jakob Neilsen (1994). Ten Usability Heuristics Retrieved from: http://www.nngroup.com/articles/ten-usabilityheuristics/
- [15] Kothari, C.R. (1985), Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
- [16] Csikszentmihalyi, M. 1990. Flow: The psychology of optimal experience. New York: Harper and Row.
- [17] Hawkins B. (2011). Software Discoverability. Retrieved from: http://www.academia.edu/2977673/Software_Disc overability
- [18] Ginsburg S. (2011). The Evolution of Discoverability. Article No. 629 Retrieved from: http://www.uxmag.com/articles/the-evolution-ofdiscoverability
- [19] Rock Leung, Joanna McGrenere, Peter Graf (2008). The Learnability of Mobile Application Interfaces Needs Improvement. Vancouver, British Columbia, Canada.

AUTHOR PROFILE

Bethuel Kipchirchir Okelo received his bachelor's degree in Information Systems and Technology from United States International University in 2011. He is a research student of Information and Technology. Currently, he is a Masters student at Masinde Muliro University of Science and Technology.

Samuel Mungai Mbuguah PhD. Currently Lecturer and Director ICT at Kibabii University College. Received his PhD. in Information Technology from Masinde Muliro University of Science and technology, Kenya in 2013.

Simon Maina Karume PhD. Currently Snr Lecturer at Laikipia University received his PhD. in Information Technology from Masinde Muliro University of Science and Technology, Kenya in 2014 where he also served as Director ICT and lecturer in IT.